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ABSTRACT

This report is divided into two main parts. The first part, The Problem of Women and Mathematics, emphasizes results of ten research projects initially funded by the National Institute of Education (NIE) in 1979. They are emphasized because the findings are current and the projects touched on all major issues. This part has sections on Sex Differences in Mathematics, Factors Influencing the Study and Learning of Mathematics, and Factors Influencing Career Interests and Choice. The second section, Where Do We Go From Here, is drawn from the book "Women and the Mathematical Mystique." This part suggests directions for research and directions for change. The document concludes with a list of references. (MP)

The Problem of Women and Mathematics

by Lynn H. Fox

A REPORT TO THE FORD FOUNDATION

[redacted]

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Preface

In preparing this report for the Ford Foundation, I summarized research literature prior to 1976 very briefly and focused on research published or conducted since 1976 that supports, clarifies, or contradicts the older studies.

In the fall of 1976 I prepared an extensive review of the literature on sex-role socialization and mathematics achievement for the National Institute of Education (NIE). That paper and two others on cognitive and biological factors related to sex differences in mathematics achievement served as a basis for an NIE conference in 1977, and the three papers were published by NIE.

That same year NIE funded ten research projects in the area of research on women and mathematics to address the critical questions suggested by those three review papers. Most of the projects were completed by the late fall of 1979. Although this report is not limited to the ten new NIE-supported studies, the results of those studies are emphasized because their findings are so current and the projects touched on all the major issues. This review is contained in Part I of this report.

Part II is drawn from *Women and the Mathematical Mystique*, edited by me, Linda Brody, and Dianne Tobin and published in June 1980 by The Johns Hopkins Press. That volume contains reports of several special programs designed to promote women's achievement in mathematics In the final chapter of the book, I speculated as to the possible remediation, intervention, and prevention efforts that may be needed to increase women's participation in the study of mathematics and the pursuit of careers in math-related fields. I suggested questions that need to be more carefully researched.

I would like to thank Linda Brody and Dianne Tobin for their help in preparing Part I of this report and to express deep appreciation to the Ford Foundation program officers, especially Terry Saario (now Director of Corporate Contributions, Standard Oil Company of Ohio), Benjamin F. Payton (now President of Tuskegee Institute), and Mariam K. Chamberlain for their support and encouragement during the preparation of this report.

Foreword

This report by Lynn Fox was commissioned by the Ford Foundation as part of an investigation into the reasons for the limited participation of women in advanced mathematics and related scientific fields. Our objective was to identify the particular problems of women in these fields and to determine what steps might be taken to meet them.

Toward this end an invitational conference was held at the Foundation in October 1980 to discuss the findings of the report and to consider possible new ways to help women surmount their difficulties with mathematics and science. The conference was attended by approximately thirty researchers, mathematicians, scientists, and policy makers representing colleges and universities, government agencies, women's advocacy groups, and private foundations. Their discussions have enriched the Foundation's deliberations about what might be done in this field in the future.

In the belief that Lynn Fox's report will be as useful to others as it has been to the Foundation and to the conference participants, we are making it available to a wider audience.

MARIAM K. CHAMBERLAIN
Program Officer
Education and Public Policy

June 11, 1981

I. The Problem of Women and Mathematics

For many years far fewer women than men have aspired to or obtained jobs in quantitative fields. Until recently, this fact was attributed to innate differences between the sexes in mathematical ability or to the small number of "career women" in the labor force. In the past decade these viewpoints have been challenged. First, more and more women are planning for and seeking careers rather than "jobs." Today the question is no longer "to work or not to work" but rather when to work and at what job. Second, recent studies suggest that the small representation of women in quantitative fields may not be the result of innate differences in ability but may be caused by early decisions not to study mathematics since preparation for a career outside the home didn't seem important. By deciding not to pursue mathematics in school, most women chose not to follow the path to jobs in quantitative fields and also delimited their career options and advancement opportunities in many related fields:

The purpose of this paper is to summarize the research literature on sex differences in mathematics The key questions to be addressed are as follows:

1. What is the nature and extent of sex differences in the learning of mathematics; the study of mathematics, and aptitude for the study and learning of mathematics?
2. What factors in the lives or education of children and young adults influence the learning or study of mathematics and the pursuit of careers which require mathematical skills or competence?
3. What factors influence the choice and pursuit of careers and to what extent are sex differences in mathematical learning, study, or aptitude related to different career outcomes for men and women?

Sex Differences in Mathematics

To understand the nature and extent of sex differences in mathematics it is helpful to distinguish among the following terms: the *learning of mathematics*, the *study of mathematics*, and *aptitude for mathematics learning*. Although these three concepts are closely related, they suggest three separate questions about the nature and extent of sex differences.

The Learning of Mathematics. The term *learning of mathematics* refers principally to achievement on tests. A crucial issue is whether or not sex differences in favor of boys on tests of achievement at the high school level are simply a reflection of the fact that boys are likely to take more mathematics courses in high school than girls do Research suggests that even if girls take as many courses as the boys do they may learn less in the classroom because they will be treated differently from boys by teachers. It has also been suggested that boys have more opportunities to apply mathematical skills outside of the classroom It is also possible that the present methods of instruction give most boys an advantage over most girls. Finally, research suggests that boys may have an advantage in the classroom because they are more self-confident in their ability to learn mathematics than girls are, and they are more motivated to learn than girls are because they are more likely to view mathematics as useful for their futures

In a 1974 review of the literature on sex differences in cognitive abilities, Maccoby and Jacklin concluded that boys and girls showed equal aptitude and achievement in mathematics at the elementary school level, but that boys consistently scored higher than girls at the secondary and postsecondary levels. Fennema and Sherman (1977) were among the first to challenge this conclusion They argued that past studies of sex differences in mathematical aptitude and achievement had not taken account of differences in exposure to mathematics study in school. Most males had completed three or four years of high school mathematics while most females had completed only one or two years. In their own study of high school students in Wisconsin, Fennema and Sherman found boys and girls who had the same number of mathematics courses scored the same in two of the four schools studied. In two schools in which boys still scored higher than girls there were also differences between boys and girls in terms of their attitudes about mathematics.

Wise, Steel, and MacDonald (1979) analyzed test data from Project Talent, a longitudinal study of 400,000 students in high school in 1960, to determine the extent of sex differences with and without controlling for the effect of course-taking. They found no sex differences among the 9th graders in the Project Talent Study in 1960, but by 1963 these same students differed significantly. The gains by males on the test were more than twice that of females in the three-year interval However, when the data were reanalyzed to control for the number of mathematics courses taken in high school, the sex differences among seniors disappeared.

In the Women and Mathematics National Survey (WMNS) of 13-year-olds and high school seniors conducted in the fall of 1978, no sex differences were found for 13-year-olds on the measures of problem-solving or knowledge of algebra, but females scored significantly better on the computation subject.

On the problem-solving subtest, however, sex differences were discovered among 12th graders. Males scored higher than females overall. Differences favoring males were also found among men and women who had enrolled in or who had not gone beyond courses in general mathematics (this includes courses in pre-algebra, business, or consumer mathematics), algebra I, algebra II, trigonometry, and/or probability and statistics. However, no differences in problem-solving were found for males and females who were enrolled in or had completed calculus, pre-calculus, or geometry.

The results of the subtests on computation and algebra for 12th graders were equal for males and females with the same exposure to math study. The composite achievement score (summing across algebra, computations, and problem-solving) for 12th-grade boys was significantly higher than for 12th-grade girls, and was also higher in the subgroups of boys and girls who had completed but not gone beyond algebra II (Armstrong, 1979).

The National Assessment of Educational Progress (NAEP) second mathematics assessment in the spring of 1978 found significant sex differences among samples of 13- and 17-year-olds on two of the three subtests. At age 13, females scored higher than males on the computation subtest and males scored higher on the applications subtest. No sex difference on the computations subtest for 17-year-olds was found but males continued to out-perform females on the applications subtest. There were no significant sex differences on the algebra subtest at either age.

When the data on 17-year-olds were reanalyzed to consider for the amount of mathematics studied, males at each level of study (general mathematics, algebra I, geometry, algebra II, and beyond algebra II) scored significantly higher on the applications subtest. Males whose highest level of study was algebra II outscored their female counterparts on computation but not on algebra, and males who went beyond algebra II scored higher than their female counterparts both in algebra and computation (Armstrong, 1979).

Thus, studies which compare men's and women's achievement in math among groups with the same exposure to study have mixed results. Sex differences on composite scores disappeared on the Proj-

ect Talent Study and for all but one of seven participation groups in the WMNS when exposure to study is the same. On separate subtests, however, there are some differences in favor of males. Thus exposure to classroom study is a major factor but not the only factor in explaining the higher score of boys on tests.

Several studies have found that achievement test items are "biased" in favor of boys in terms of content or sex role appropriateness and that such bias relates to success on these items (Tittle, McCarthy & Stechler, 1974; Ekstrom, Lockheed & Donlon, 1979). The bulk of "biased" items are found on verbal subtests rather than numerical ones It is possible that the applications subtest in the NAEP study and the problem-solving subtest in the WMNS study contained biased items. If so, that could be one reason for differences in scores in favor of men.

Another possible reason for sex differences on test performance even among groups with equal study is that learning and application of mathematical knowledge and skills outside of school may be greater for men. Evidence for this hypothesis comes from anecdotal or indirect sources rather than from direct empirical study. One might argue that computation and algebra subtests used in the WMNS study measure the learning in the classroom more directly than do the applications and problem-solving subtests. These latter tests may reveal different learning experiences of boys and girls outside of school

The Study of Mathematics. The term *study of mathematics* refers principally to enrollment in mathematics courses, particularly advanced elective courses at the high school level Most states require two years of course work in mathematics for graduation from high school, but the level of courses is not specified. In some studies the number of semesters of course-taking is examined while others report on the actual courses taken and differentiate between general or business math and the sequence of courses leading to and through calculus. A few studies note that the "choice" to pursue mathematics study may occur prior to high school, particularly in schools which offer algebra I as an elective in the 8th grade.

Sex differences in the study of mathematics at the high school and postsecondary levels has long been noted but it was not until 1972 that it received much attention as a factor related to women's choices of and success in careers. Lucy Sells used the term "critical filter" to describe how failure to study mathematics could affect women and some minority groups. Nationally representative samples such as the

Project Talent Study (1960), and the National Longitudinal Study (1972), confirm differences in math study between males and females (Wise, Steel & MacDonald, 1979).

More recent studies, however, are somewhat contradictory as to the extent of the gap between the sexes in mathematics course-taking at the high school level Data collected by the Office of Civil Rights in 1976 as published by the National Center for Educational Statistics (Dearman & Plisko, 1979) indicate enrollment in advanced mathematics courses was approximately equal for girls and boys. The NAEP second mathematics assessment, Spring 1978, however, found a significant sex difference in enrollments in or completion of courses in trigonometry, pre-calculus and calculus but not in enrollments in or completion of algebra II for 17-year-olds. The WMNS study in the Fall of 1978, on the other hand, reported sex differences in participation of algebra II, probability and statistics, and business math (the latter had higher participation rates for women while the first two had higher participation rates for men) but no differences for all other levels including trigonometry, precalculus, and calculus.

According to a study of high school seniors in 1978 by the College Entrance Examination Board, approximately 63 per cent of college-bound males but only 43 per cent of the females had taken four or more years of high school mathematics. The proportion of females who took the advanced placement exams for calculus was still very low in 1979 (34 7 per cent of those taking the AB level exam and 25.5 per cent of those taking the BC level exam were women).

In a study of high ability students who participated in a talent search as seventh graders in 1973, sex differences were found on course-taking, particularly at the pre-calculus level. By the end of twelfth grade, 40 per cent of the girls and 68 per cent of the boys had taken calculus (Fox, Brody & Tobin, 1979). Seventh graders in the 1978 talent search, however, did not differ by sex with respect to plans to study calculus. Sixty-four per cent of the boys and 73 per cent of the girls said they planned to take it in high school. Thus, among high ability students, sex differences in course-taking may be disappearing as a result of increased participation by girls.

Thus one gets a strong feeling of change starting near the middle of the past decade at the high school level. The differences in the findings of some recent studies may reflect the fact that change is still occurring and more rapidly in some age, ability, and/or geographic groups. Thus, sampling differences may account for variations in findings. One might hypothesize that conditions in California, Maryland, and Wis-

consin, for example, are changing at a faster pace than elsewhere because they have been the focus of several studies and intervention projects. Even if sex differences in course-taking are lessening, more than half the college-bound group of today's women are enterting college without the prerequisite mathematical background for entrance into the higher paying technical fields.

At the college and university level changes are occurring in the proportion of bachelor's, master's, and doctoral degrees awarded to women in technical fields (Dearman & Plisko, 1979; Grant & Lind, 1979) Four per cent of those who received the bachelor's degree in engineering in 1976-77 were women, and this was ten times the percentage of women who earned a bachelor's degree in 1966 In 1976-77, 20 per cent of the bachelor's degree recipients in the physical sciences were women, an increase from 13 5 per cent in 1966 In the mathematical sciences women earned 41.5 per cent of the bachelor's degrees in 1976-77. This was an increase from 33 3 per cent in 1966

The percentages of women receiving the doctoral degree in mathematics and the physical sciences more than doubled between 1965-66 and 1976-77 (Dearman & Plisko, 1979, Grant & Lind, 1979) At the same time, however, the proportion of women receiving medical degrees tripled, and the proportion receiving law and dentistry degrees increased by seven times. Despite rapid gains, women still accounted for a small part of the degrees granted in all these fields in 1976-77 they received 22.5 per cent of the law degrees, 19 per cent of the M D degrees, 13 per cent of the doctorates in mathematics, and 10 per cent of those in physics, and only 7.3 per cent of the degrees in dentistry. Even in fields such as education and psychology in which females dominate at the undergraduate levels, almost two-thirds of the doctoral degrees were earned by men.

Although women are now entering colleges at about the same rate as men, there are still sex differences in intended fields of study Among college-bound high school seniors in 1978, four times as many males as females were headed for a major in the physical sciences or related areas (26 1 per cent of males as compared with 6 3 per cent of females) The percentage of females entering the biological sciences and related areas is higher than that of men, but this grouping includes a large number of women entering health services fields One field that women are entering in large numbers is business: the number planning to major in the area is now about equal to men As recently as 1976-77, only 23 4 per cent of the bachelor's degrees in business were earned by women (Dearman & Plisko, 1979; Grant & Lind, 1979)

Not only do fewer women than men elect majors in the mathematical and physical sciences but the attrition rates for women seem to be higher than for men. In a study of young women who had participated in an NSF science or mathematics program in high school it was found that 70 per cent had envisioned science careers while in high school but 85 per cent of this group changed career goals away from science after entering college (Christman. Vidulick. Gralle & Kirk. 1976). In 1976. of the college senior women who had declared quantitative studies as a major as freshman four years earlier. only 41 per cent were still enrolled in a quantitative field as compared to 56 per cent of the men in the national sample (Melone. 1980). When analyzed by semesters of high school mathematics. one sees that slightly fewer than half the women who had six semesters or more of high school mathematics persisted in a quantitative major as compared to 60 per cent of the men. and only 29 per cent of the women and 40 per cent of the men who had taken less than six semesters were still enrolled in quantitative areas This differential completion rate must be reviewed in conjunction with the initial difference in choice of a quantitative major in the first year of college (15 5 per cent of women and 36.2 per cent of men) to see its full impact in terms of eventual careers.

Aptitude. Sex differences in aptitude for the study of mathematics is difficult to assess due to the problems of measuring aptitude independent of learning The term *aptitude* is used herein to mean an innate predisposition to learn or not to learn concepts and skills with ease and rapidity. presumably without regard to the mode or speed of presentation of the material Thus an individual who solves a problem before being taught the specific algorithm for solving it has more "aptitude" than the individual who can solve the problem only after studying the algorithm. If the time required to master a learning task is shorter for one person than another the former has more "aptitude" than the latter.

In the classic textbook in standardized testing Anastasi (1976) notes the problem of assessing aptitude independent of the influence of experience or instruction. The distinction between aptitude and achievement tests is based on the specificity of the test items to curriculum. Yet tests which purport to assess aptitude are rarely thoroughly analyzed and most often claim only that test results correlate with later "achievement" without reference to test-takers' previous learning experiences. Thus a major problem in determining the extent and nature of sex differences in mathematics aptitude lies in the choice of what one will ac-

cept as a measure of aptitude. This issue is further complicated by whether or not one assumes that aptitude for learning mathematics is dependent upon special ability for perceiving spatial relationships.

This Scholastic Aptitude Test-Mathematics (SAT-M) purports to be a measure of aptitude as opposed to achievement It is taken by college-bound high school juniors and seniors, and assumes the study of mathematics through but not beyond algebra II and plane geometry Donlon (1971), however, noted that a sex difference of 40 points might be expected due to the "bias of test content." and a 40 point difference in favor of males is about what is usually found When the SAT-M is given to highly able 7th graders the difference in mean performance is about 35 points, but twice as many boys as girls score 500 or more (Fox & Cohn, 1980) This difference can not be explained by differences in course-taking in school. Perhaps some of the differences result from more out of school use of mathematics among gifted boys, or perhaps gifted girls have a poorer test-taking strategy for the SAT-M at grade 7

There is no strong evidence to support or refute a biological or genetic basis for sex differences in mathematical ability. Mathematical ability seems too complex to be explained in terms of the heritability of a single trait. While there is a biological difference in terms of body chemistry, it is not clear how this affects the development of mathematical ability. It has been hypothesized that there are sex differences in the development and organization of the brain that leads to differential patterns of abilities for boys and girls Thus, while one cannot disregard totally the question of a biological basis for differences, the research at present is far from conclusive. Indeed there is not agreement among researchers and educators as to the extent of aptitude differences. Benbow and Stanley (1980) argue that differences on the SAT-M are indicative of male superiority Others would argue that these differences reflect the impact of social conditioning that directs girls away from an interest in learning mathematics, differences in test content and/or test-taking strategies. For example, until recently sex differences in spatial abilities in favor of males were believed to be certain (Maccoby & Jacklin, 1974, Harris, 1978) and thought by some to be related to sex differences in mathematical achievement (McGee, 1979) Several recent studies have shed doubt as to the extent and nature of differences in spatial abilities (Armstrong, 1979; Connor, Serbin, and Schackman, 1977; deWolf, 1977; Nash, 1979; Sherman and Fennema, 1978, Sherman, 1979, Smith and Litman, 1979; Smith and Schroeder, 1979). Even if as a group males are superior it is

important to remember that not all boys are better than all girls. Sex differences in career outcomes cannot be explained in terms of 40 point mean differences on tests like the SAT-M

Factors Influencing the Study and Learning of Mathematics

Most of the recent studies on sex differences in mathematics have focused on factors that may influence men or women to study or not to study mathematics, particularly in high school. A great deal of attention has been paid to the influence of "significant others" such as parents, teachers, counselors, and peers. The way schools are organized, and society's perception of mathematics as a male domain may also be significant. Students' attitudes towards the study of mathematics, their self confidence, career interests, and values have also been shown to influence course-taking decisions But these factors are generally viewed as intermediary variables that result from the direct or indirect influences of significant others and societal values. Several studies have attempted to specify the order and direction of causation by means of path analysis. The results of these studies are not in agreement perhaps in part because of differences in the choice or measurement of the key variables It is also likely that different factors affect individuals in different ways and degrees. At present it seems best to examine each of the variables separately

Counselors. The impact of counselors and counseling programs upon the course taking plans and career goals of young women with respect to the fields of mathematics and science has not been well studied Most studies in which this is discussed are retrospective reports by young women of the counseling they did or did not receive. Such studies, even those as recent as 1975 and 1976, have indicated that counselors have not encouraged and in some cases attempted to discourage women from the study of mathematics and the pursuit of mathematical or scientific careers (Casserly, 1975, Haven, 1972; Luchins & Luchins, 1980). In the WMNS study, counselor encouragement was significantly related to mathematics participation of 12th grade males but not females.

A study funded by NIE in 1977-79 did survey counselors directly. In this study counselors did not appear to have biased views of women's potential for the study of mathematics or pursuit of such careers (Stallings, 1979). This same study, however, was not able to find any positive effect of career counseling programs upon female participation in courses. An on-going study of adult women who return to or enter

college after raising a family finds that such women are not actively encouraged to study mathematics or pursue careers in areas that require mathematical skills (Richmond, Downs & Ellinghaus, 1979).

It should be noted that in colleges and universities the role of academic advisor is most often filled by college professors Males tend to dominate the professional roles in the sciences and they are more likely to select males than females as their protege's This may be one factor in the sharp decreases in master's and doctoral degrees earned in the sciences by women and the higher attrition rates for women than men in undergraduate quantitative majors

One recent survey of students in vocational technical programs and those in college-bound or academic programs in high school found students felt a need for academic and career counseling but their counselors when surveyed viewed these areas as low priorities or areas in which they were poorly trained (Richmond, Tucker & Martin, 1979) It seems likely that the potential of counselors to help females make intelligent decisions about educational and career plans has not been realized

Teachers. Efforts by teachers to encourage the pursuit of courses and careers in mathematics or to actually recruit students to advanced level courses in mathematics and science seem to have a positive effect, or at least are perceived to have had an effect by those women who do pursue courses or careers in these areas (Casserly, 1975; Casserly, 1980, Luchins & Luchins, 1980). The WMNS found young women's perceptions of teacher encouragement along with father's educational expectation to be the best predictors of course-taking. Presumably teachers' encouragement of the girls' pursuit of mathematics or science was related to the teachers' view of female abilities In studies prior to 1976 many teachers viewed mathematics as a male domain (Ernest, 1976; Levine, 1976).

Several studies have found differences in the frequency and nature of teacher interactions with male and female students at the elementary and secondary school levels. In a study of 2nd grade classrooms, teachers made more academic contact with girls in reading and with boys in mathematics (Leinhardt, Seewald & Engel, 1979). In mathematics classes at the secondary level, teachers initiate more contact with males than females even when there are no differences in the number of student initiated contacts (Bean, 1976; Stallings, 1979). Math teachers have been found to give different feedback to men and women for wrong answers—telling men to try harder while praising

women for just trying (Dweck & Repucci, 1973)—which is consistent with the "learned helplessness" syndrome postulated by Dweck and Bush (1976) In some classrooms teachers gave the most praise to the boys they thought were highly able while giving the least to the highly able girls (Parsons, 1980) The long-term consequences of such treatment differences can be inferred but have not been empirically verified.

The effects of teachers' instructional style, mode, or choice of content upon learning outcomes and attitudes of students in mathematics is not well researched It has been found that spatial abilities are related to mathematical achievement and spatial ability is not a part of the general mathematics curriculum. In a recent study funded by NIE (Connor, Serbin & Schackman, 1977) performance on a spatial task was substantially improved for girls but not boys by a specific instructional strategy which took only fifteen minutes. One might speculate that greater attention to the study of instructional content and mode would shed light on a wide range of questions about individual student learnings in the classroom.

Another variable not well studied is the mathematical competency of the teacher, particularly at the elementary and middle school level. A logical argument can be made that teachers who are not well trained in mathematics, and especially those who have some anxiety or negative feelings in relationship to mathematics, are poor teachers of, or models for, mathematical competency and interests, since teachers at the elementary school level are largely female they provide especially poor models for girls.

Parents. In a 1976 review of the literature of the effects of sex-role socialization on mathematics participation and achievement it was concluded that support and encouragement from parents was a crucial factor in students' decisions to elect or not elect mathematics courses in high school, and for girls the influence of the father was even greater than that of the mother At the same time parents were found to have lower expectations for girls than boys and to foster mathematical self-confidence and course-taking less for girls than boys (Fox, 1977).

More recent studies confirm the above findings. The WMNS found the perception of father's education expectation to be the most significant predictor of course-taking for girls while the perceived encouragement and educational expectations of both parents predicted participation for boys (Armstrong, 1979). Parental expectations were also found to be related to course-taking in the NLS study of the high school class of 1972 (Melone, 1980). In two studies the effect of

perceived parental expectations were compared with the effect of the parents as role models, and it was expectations, not modeling, that was the significant factor (Armstrong, 1979, Parsons, 1980) In the Parsons study (1980) parents saw mathematics as less important for daughters than sons and believed that mathematics is more difficult for girls than boys. Stallings (1979) found that parents' support of and expectations for high school boys and girls who continued in their study of mathematics differed significantly from parents' expectations for students who did not continue.

Peers. Although common wisdom and some research suggest the importance of the peer culture upon attitudes and behaviors of students, especially adolescents, the dynamics by which peers influence course-taking and achievement in mathematics is not well-documented In elementary school girls believe girls are best in mathematics and boys believe boys are best (Ernest, 1976, Boswell, 1980); but when asked about adults, both sexes see males as more involved in mathematical activities (Boswell, 1980). In the high school years some studies found a shift of attitudes among girls so that girls see mathematics as decreasing in importance for girls and consider boys superior in math (Ernest, 1976; Boswell, 1980). Several studies have found that male adolescents are more likely than females to stereotype mathematics as male domain although the degree of stereotyping by boys is not always great (Sherman & Fennema, 1977; Fox, Brody & Tobin, 1979; Sherman, 1979).

Anecdotal accounts illustrate how peer pressures can operate One mathematically gifted girl dropped out of an accelerated mathematics program only because her best friend did so (Angel, 1974) Although many mathematically gifted males skip grades or take college courses early with little or no problem (Stanley, 1973), mathematically gifted girls are very reluctant to skip a grade or take college courses early because of fear of peer rejection. One girl was ready to abandon a grade-skip in the first week of school and return to the lower grade because she had no friend with whom to eat her lunch (Angel, 1974) Casserly (1975) found that girls who took advanced placement courses in mathematics remarked on the importance of a girlfriend's support to help deal with the disapproval of boys.

Self-confidence. Several recent studies funded by NIE have found self-confidence as a learner of mathematics predicts participation in mathematics courses in high school (Armstrong, 1979; Sherman,

1979) Presumably self-confidence and course-taking should be self reinforcing so that successful course experiences will increase self-confidence, and increased self-confidence will lead to more course-taking. Brush (1979) noted females and males became more negative towards mathematics as they went from grades 6 to 12 and mathematics became increasingly difficult. All three research studies concluded that the fostering of self-confidence in the elementary and junior high school years may be critical for participation in high school mathematics by both males and females.

Numerous studies have reported sex differences in self-confidence (higher confidence of men) with respect to academic achievement tasks, including mathematics (Fox, 1977). Studies by Sherman and Fennema (1977) and Sherman (1979) have found a strong relationship between responses to the confidence subscale of the Fennema-Sherman Mathematics Attitude Scales and performance in achievement tests for both boys and girls. For girls (but not for boys) self-confidence scores were related to perceptions of mathematics as a male domain Girls who perceived mathematics as neutral were more likely to be self-confident.

The extreme lack of self-confidence has been termed *math anxiety* or *mathemaphobia* More females than males report being math-anxious and such feelings are presumed to inhibit learning in the classroom and lead to the avoidance of the study of mathematics whenever possible. Anecdotal evidence suggests that math anxiety is a learned response set and learned more by women than men due to societal beliefs about female innate inferiority in mathematics.

Usefulness of Mathematics and Career Interests. Numerous studies before 1976 found that the perceptions of the usefulness of mathematics for one's future differ for males and females and are related to course-taking plans and behaviors (Fox, 1977.) New studies undertaken between 1977-79 indicate that the perception of the usefulness of mathematics is still an important prediction of course-taking for girls (Armstrong, 1979; Sherman, 1979; Stallings, 1979). The perception of the usefulness of mathematics correlated with achievement test scores in the WMNS study. The perception of the usefulness of mathematics is related to career interests.

There is considerable evidence to suggest that the decision to study or not study advanced mathematics courses in high school is influenced by students' career interests in grades 9 or even as early as grade 7 (Fox, 1977). The recent analysis of longitudinal data from Project

Talent confirms the importance of early career interests (Wise, Steel & MacDonald, 1979) as does data from the WMNS survey (Armstrong, 1979) Most studies find more males than females expressing interest in careers of a scientific or technical nature (Fox, 1977) but a recent study of highly able students found no significant differences in career interest whereas such differences had been found among such students in previous years (Fox & Denham, 1974, Fox, 1978, Fox, Brody & Tobin, 1979) Perhaps differences in career interests are gradually changing A more detailed discussion of factors that influence career interests is provided in a later section of this paper

School Variables. Three of the ten NIE grants on Women and Mathematics in 1977-79 found school-related variables that were associated with increased mathematics participation or achievement of females Wise, et al (1979) found accelerated curriculum offerings in science were related to higher than expected female achievement and less interest in office careers for women Casserly (1979) found that the practice of "tracking" into accelerated or special academic programs in the upper elementary school grades was a major factor contributing to girls' later participation in an advanced placement calculus class Fox, Brody & Tobin (1979) found that girls benefited from participation in special accelerated programs for the mathematically able in terms of career commitment, acceleration of learning, course-taking plans and achievement.

Male Domain. There is little doubt that the perception of mathematics as a male domain is common As Casserly (1975) points out, traditionally the physical sciences and mathematics have been male provinces, and relatively few women have crossed the borders to seek eminence in these domains.

While investigating high school students' attitudes toward mathematics, Sherman and Fennema (1977) addressed the issue of mathematics as a male domain and found that the boys, more than the girls, rated mathematics as a male domain. They hypothesized, however, that these girls live in a community where the women's movement receives much publicity. When the girls were asked to respond to such an item as "Studying mathematics is just as appropriate for women as for men" they agreed with the statement, but when it came to course selection their behavior was more stereotypic. Thus, while the study did not document that girls more than boys believe mathematics is a male domain, it did find that the girls' actions contradicted their words.

The stereotyping of mathematics as a male domain did relate to both female achievement and course-taking (Fennema & Sherman, 1977)

Sherman and Fennema (1977) also pointed to the fact that mathematics teachers tend to be male (69 per cent in the city studied in 1974-75) and this contributes to the impression that mathematics is a male domain. There is also a tendency for the more advanced mathematics courses to be taught by males, lending additional support to the overall impression that mathematical thinking is a male province

In a study by Farley (1969) students were asked to rank in order six reasons for girls' lack of interest in mathematics oriented work The second choice for girls was that men do not want girls in the mathematical occupations. Boys rank this reason fourth Thus, this study suggests that girls feel more strongly than boys that there is male prejudice against the girls' engaging in mathematics-related work

Casserly (1975) found that many guidance counselors still believe that careers in mathematics and mathematics courses are male domains The fact that teachers perceive boys as better at mathematics than girls (Ernest, 1976) is also suggestive of their sex-typing of mathematics

The evidence that parents sex-type mathematics comes largely from indirect rather than direct measures. For example, Ernest (1976) found that after grade 6, both males and females tended to seek homework help in mathematics from fathers rather than mothers Parents of mathematically gifted boys were more likely to report having bought scientific and mathematical games and toys for their sons than were the parents of girls. If parents do sex-type mathematics as a male domain, this should lead to differential expectations of behavior for sons versus daughters. There is some evidence to this effect. Fathers who regard mathematics as a more masculine than feminine pursuit had higher expectations for their sons in mathematics than did fathers who sex-typed mathematics less (Hill, 1967). A similar relationship was not found for mothers.

Carney (1974) reports that racism and sexism are still the role in children's books and textbooks. Secondary school textbooks are no better. Trecker (1973) reports that so far as the secondary school curriculum is concerned, humanity is masculine. Television programs typically reinforce traditional sex-role stereotypes. Thus, the general communication from society is sex-biased.

Much time and attention has been given to sex typing in reading books for children, but relatively little to their mathematics texts. This is probably due to the fact that it is assumed that numbers cannot be sex-

typed It is interesting, therefore, that the few studies that have been done show that the mathematics textbooks used by both elementary and high school students do support a stereotyped view of women's role in society (Jay, 1973; Federbush, 1974, Jay & Schminke, 1975).

Factors Influencing Career Interests and Choice

Sex differences in career interests and aspirations have been well documented and have been found among students as early as kindergarten and first grade (Looft, 1971, Schlossberg & Goodman, 1972). There is considerable evidence that adolescent males show more interest in mathematical and scientific careers than girls and that these interests parallel and predict later outcomes for adults (Gottfredson, Holland & Gottfredson, 1975; Wise, Steel & MacDonald, 1979). But as Astin noted in 1974, there is a paucity of good research to explain the dynamics of the development of career interests in childhood and adolescence Generally sex differences in career interests are assumed to be a result of societal stereotypes of appropriate careers for men and women, the societal pressure on women to put family before career, and the lack of role models for young women to emulate (Fox, 1977).

Women who change college majors away from scientific fields differ on measures of independence and self-confidence from those who persist in these fields (Brown, 1976). Autonomy and self-confidence have also been linked directly to achievement and/or aptitude test scores and/or course-taking (Astin, 1968; Astin, 1974; Astin & Myint, 1971; Sherman, 1979). Presumably independence and self-confidence are shaped by both home and school experiences.

The importance of exposure to salient role models upon career interests and aspirations has been pointed out by several studies (Lantz, West & Elliott, 1976, Levine, 1976). Direct encouragement and stereotypic views held by significant others in a young woman's life also influence aspirations and interests in positive and negative ways. The following paragraphs detail the influences of significant others and the section closes with young women's views on discouragement and encouragement in choosing a scientific career.

Career choices, particularly those in non-traditional careers, including mathematics and science, appear to be influenced directly and indirectly by teachers. Although women undergraduates majoring in mathematics reported more discouragement about careers in mathematics than did men, adult women mathematicians often cite the encouragement of a teacher as a major factor in their choice of careers (Luchins & Luchins, 1980).

Teachers of mathematics and science at the secondary and post-secondary levels have potential as role models. Students who switch away from a science career in college cited lack of role models as a reason (Christman, Vidulick, Dralle & Kirk, 1976). Fox (1974) found that female enrollment in undergraduate majors paralleled the proportion of female teachers within the discipline. A study by Stake and Granger (1978) found that among high school seniors, males and females with the highest science career commitment were those who had same-sex teacher models whom they perceived as moderately or highly attractive, and students with the lowest science career interest were those who had same-sex models whom they perceived as low in attractiveness. Same-sex teachers were associated with greater career commitment only among those students who reported large amounts of individual teacher contact. Unfortunately, the opportunity for same-sex individual teacher contact in mathematics is less for girls than boys in most schools.

Counselors do not appear to play a major role in the development of students' career interests. They have, however, been remembered by young and adult women more for their discouragement rather than their encouragement of the pursuit of science careers (Levine, 1976; Casserly, 1979).

In 1972 Entwisle and Greenberger concluded that peers, especially male peers, exerted considerable influence in adolescent girls' occupational aspirations. Mathematically talented 8th grade boys surveyed in 1978 did not expect their wives to have a major career commitment outside the home (Fox, Brody & Tobin, 1979).

When women elect a career it is based on what they feel the important men in their lives can tolerate (Hawley, 1971, 1972). Thus efforts to increase women's participation in scientific careers should not overlook the problem of men's views of appropriate work for women. A 1978 study of undergraduate men and women found them to hold sex-role stereotypic views of 16 of the 20 occupations they were asked to rate, and stereotypic views of careers labeled "masculine" were only minimally modified after exposure to a non-sex-biased career information treatment (Yanico, 1978).

The role of the parent in the development of career interests and aspirations has not been well-researched in recent years. Older studies suggest that working mothers have positive influences on their daughters' career aspirations whereas identification with or support and encouragement from the father are regarded as factors in the pursuit of mathematical and scientific careers (Astin, 1968; Helson, 1971).

McLure and Piel (1978) surveyed college-bound high school senior women who had participated in an NSF program intended to stimulate interest in science/technology careers but who indicated they did not plan a program of study in fields of mathematics, science, or technology These women were asked why fewer women than men pursue science and technology careers in general and asked to identify any barriers that had specifically reduced their own interest in such a career The four reasons cited as most important in general and for themselves personally were doubts about combining family responsibilities with career demands; the perception of preparation for such careers as long, hard, and expensive, lack of encouragement from counselors and teachers, and lack of information about science/technology careers When asked what factors might facilitate women's entry into such careers, they cited encouragement from family and changing attitudes about what is appropriate work for women as most crucial These results are consistent with earlier studies on the barriers to careers in science (Astin, 1974, Rossi, 1965; Smith, 1976).

II. Where Do We Go From Here?

Although women make up about 40 per cent of the labor force, they hold only a third of the professonal and managerial positions and are markedly absent from the ranks of scientists and engineers. In 1976 women held about 13 per cent of the positions in mathematics, computer science, and the life sciences, only 7.5 per cent of the positions in the physical sciences, and less than 1 per cent of those in engineering (Dearman & Plisko, 1979). In light of the preceding review of the literature, this situation seems to be caused primarily by social attitudes and actions that inhibit the study of mathematics and discourage women from pursuing careers rather than by basic sex differences in aptitude.

Clearly, sex differences in the study of mathematics in the high school years has been a major barrier to career equity for women. Deciding not to study mathematics can be seen as both cause and effect in a somewhat circular pattern of reinforcing stereotypes and behaviors. Many girls do not take advanced courses which are optional because they are not encouraged to do so by parents and counselors, but also perhaps because they have less self-confidence, perceive mathematics as difficult, and have less clear career goals. The fact that

they do not study mathematics and science at advanced levels limits their career options and attainments and contributes to the stereotype of mathematics as a male domain. This in turn leads women to receive less support and encouragement to pursue careers in the sciences.

In the mid-1970s this problem was recognized and some efforts were made to increase the participation of women in high school courses. Recent studies do indicate that sex differences in course-taking in high school may be lessening as we enter the 1980s Alas, these same studies suggest that the problem of sex differences in the learning of mathematics may not be totally eliminated by increasing the participation of women in advanced courses Some sex differences in achievement on tests of the applications of mathematics and mathematical problem-solving have been found in large samples of students who were matched on course-taking experiences.

Today the problem of women in mathematics seems more complex than it appeared just a few years ago Arguments for innate sex differences in aptitude seem weaker than before, but the issue has not been totally resolved. Social factors that inhibit the pursuit of the study of mathematics and the pursuit of careers have been identified but it is not clear that these factors can explain all of the differences in the learning of mathematics.

It would seem that if we are to understand the problem of women and mathematics we need to know much more At the same time, our present knowledge does suggest some strategies for remedial programs, for intervention, and for prevention. The remainder of this report considers needed research and strategies for change

Directions for Research

There are several interesting directions for new research They can be considered under three broad headings. First, classroom studies, especially of new remedial or intervention programs, are needed to help determine how the social factors that discourage women in mathematics and science can be lessened. Second, longitudinal descriptive studies and naturalistic observation should be conducted to help in understanding the social processes within school and homes that promote or inhibit achievement in mathematics Third, intensive case studies of mathematically gifted students, their parents, and teachers should be conducted.

Experiments in Change. Several different types of remediation and intervention have been started, but there is much to learn about which

strategies are most effective Among specific research questions are.

1. How lasting are the effects of girls' exposure to a few role models for a short period of time?
2. Are video-taped or filmed presentations as effective as exposure to live role models in encouraging girls to pursue mathematics?
3. Can negative teacher attitudes about women and mathematics be changed through information and training, and would such training effect their behaviors in the classroom?
4. Would a same-sex mathematics program affect women's achievement and self-confidence? In mixed-sex elective classes, is there a critical number of girls needed to prevent attrition?
5. What is the most effective way to teach the applications of mathematics to a variety of career areas? Should career education be separate from or integrated with the regular mathematics program?
6. Would requiring four years of high school mathematics be an effective way to increase women's interest in and study of the subject?
7. If advanced mathematics courses were taught with greater emphasis on applications to problems in the social sciences and economics, would they be more appealing to girls than current courses?
8. At what stage of women's schooling might intervention be most effective in encouraging them to take mathematics?

Longitudinal and Observational Studies. There are many general questions about the process of sex-role socialization, the dynamics of family environments, and the social environments of schools and classrooms that are of particular interest in considering women and mathematics. For example:

1. What child-rearing philosophies and practices promote intellectual interest and competence (especially in mathematics), and motivate a child to achieve?
2. To what extent are children's abilities and interests shaped by their play experiences and access to certain types of toys in the preschool years?
3. How do boys' and girls' values and interests develop from childhood to adolescence, and how are these values and interests shaped by significant others?
4. What are the dynamics of the adolescent peer culture that promote or inhibit girls' mathematical and scientific interests?

5. In what ways do teachers selectively reinforce different behaviors with respect to academic achievement in girls and boys?
6. Are society's attitudes about appropriate careers for women (especially in mathematical and scientific fields) changing? Are there fewer overt and covert barriers to women's success in professional careers now than ten or twenty years ago?
7. Are expectations of parents more or less potent than expectations of teachers or peers in promoting self-confidence with respect to mathematics?

The Mathematically Gifted. A prime group of interest are those boys and girls who exhibit superior mathematical reasoning ability as early as grade 7. Such students are the most likely candidates for high level professional careers. Research is needed to explore the family backgrounds, educational experiences, and amount of support and encouragement these students receive in order to help explain sex differences in achievement in mathematics and in math-related careers Among specific questions are:

1. In what ways are mathematically able boys and girls alike and different with respect to such variables as self-confidence, willingness to take educational and intellectual risks, perception of usefulness of the study of mathematics, enjoyment of mathematical activities, career interests, and access to positive role models? What are the relationships between these variables?
2. What relationships exist between mathematical abilities and interests and socioeconomic variables such as education or occupation of parents; between mathematical abilities and family constellation variables such as birth order and sex of siblings?
3. How do mathematically able youths perceive the support they receive from parents, teachers, and peers? Are perceptions of support independent of socioeconomic and family constellation variables and are they different for boys and girls?
4. What attitudes and behaviors of parents foster or inhibit the development of mathematical interest and skills? Do parents consider mathematics more appropriate for men than women?
5. Do mathematically able boys and girls learn mathematical and related skills at home before entering school or before topics or skills are taught in school? Who teaches them? Are there differences between boys and girls or between girls high and girls low on measures of self-confidence and enjoyment? Is the learning of mathematics in the home related to measures of self-con-

fidence, enjoyment, career interests or to socioeconomic and family constellation variables?

6. What are the characteristics, attitudes, and behaviors of teachers who are perceived by highly able girls as having had a positive influence on the development of their self-confidence and interest in the study of mathematics and/or related careers?

Directions for Change

If one believes that sex differences in mathematics course-taking in high school, college, and graduate training and the pursuit of careers in fields which require high level mathematical skills are at least partially caused by social-environmental and educational factors, strategies for change must seek to reduce or eliminate the sex-typing of mathematics and related careers as masculine domains and provide more encouragement and support for women's achievement in the classroom and on the job It appears that such support must begin early in the home and be reinforced in the schools and by society at large. At present, there is a need for three different approaches: remediation for some adult women, intervention for young women now making course-taking and career decisions, and the prevention of future inequities in the mathematics education of young women.

Remediation. How might one remediate women who are potentially good at mathematics but have avoided studying it? Two populations of adult women seem the most likely candidates for remedial programs. women who are entering the labor force or returning to school after a period in the home, and women who are currently employed and wish to advance within their career field or shift to a new career field in which new mathematical skills are necessary or desirable.

The program described by MacDonald (1980) is an excellent model for programs for such women. The MacDonald model uses sympathetic female teachers as role models and female peer group reinforcement Diagnostic testing and sequential training of basic skills enhance feelings of competence before the student ventures into more advanced mathematics courses. It is interesting to note that for some of the students in MacDonald's classes, career aspirations were raised after a successful mathematical learning experience. On the other hand, the initial entry into the program was typically motivated by students' needs to prepare for a career.

MacDonald's model is not, however, the only model for remedial purposes. An internship-mentor model for professional women and

minority males has been developed to increase the mathematical/statistical research skills of educators and social scientists (Epstein, 1979). Sheila Tobias (1978) advocates a counseling approach to reduce "math anxiety" before or in conjunction with mathematics courses for adult "avoiders" or "phobics."

To date, too little experimental research has been done to determine precisely what program characteristics are most helpful for specific groups of adult women. It appears that training should ideally be conducted in a nurturing environment, such as the MacDonald program, and should combine career counseling with sound principles of diagnostic-prescriptive teaching to close the "gaps" in a woman's mathematical background before launching her into the "mainstream" of college mathematics courses.

Intervention. The target population for intervention attempts would be young women and girls who have not yet completed high school or college, for whom the choices of careers and course-taking are still open or reversible. A key group within this population would be mathematically talented adolescents as described by Fox and Cohn (1980), and Brody and Fox (1980). Intervention can have one or more of three goals. It can be aimed at influencing girls' attitudes and behaviors directly; it can seek to make changes in the standard learning environment, or it can try to influence attitudes and behaviors of the significant others in a girl's life, such as parents and teachers.

Attempts to change girls' attitudes and behaviors directly by means of special extra-curricular activities include career education classes, counseling sessions, and other types of experimental programs aimed at broadening career horizons, influencing course-taking plans, and increasing their self-confidence as students of mathematics. One-day career workshops designed to expose high school and college students to women role models who are employed in business, government, industry, and academia have been funded by the National Science Foundation for several years. A good example of this type of program is the series of workshops conducted by the Lawrence Hall of Science in Berkeley, California. A more intensive career awareness experience which included some instruction in statistics and computer science is described by Tobin and Fox (1980). Another approach recommended for high school students is an internship-mentor program in which students are assigned to a laboratory or other work setting under the direction of an interested woman scientist or other professional.

It is not yet clear whether direct intervention of this type is best done

with groups of girls or with mixed-sex groups. There appear to be some advantages to having an all-girl program; for example, girls may be more willing to take intellectual risks or explore feelings and concerns more openly when there are no boys in the group. On the other hand, sexist attitudes or beliefs of male peers also need to be changed so that they can accept and support changes in attitudes and behaviors of the girls. Most girls will still want to date and marry. It may be wasted energy to raise or change women's career aspirations and commitment if their future boyfriends and husbands will not support and encourage their career and educational activities. The two-career family can only be successful if both partners agree on the values and goals for each family member. Perhaps career education and counseling should utilize both mixed- and same-sex groups.

Although direct intervention as described above can be highly successful in heightening girls' perception of the value of the study of mathematics and raising or expanding career aspirations, such programs may not have lasting effects if there are no concomitant changes in their mathematics learning environments or the home. You may get the girls to sign up for more mathematics and science courses, but they may not continue in them or enjoy them if the climate of the class or the behaviors and attitudes of the teachers are negative or nonsupportive. If the new values of the girls conflict with those of their parents, the girls may not have the ego-strength or desire to oppose their parents' views. Thus, direct intervention programs may be most potent if they are accompanied by changes in the school setting and the home.

Changes in the school setting, and the mathematics classroom in particular, could involve a number of administrative and curriculum changes, such as simply requiring all students to take four years of mathematics and science in high school. If advanced mathematics, like senior year English, were perceived as equally necessary for all students, perhaps achievement differences between the sexes would be greatly reduced. This might be an easier solution than trying to increase the numbers of girls in advanced classes by less direct measures. Also, early identification of the mathematically able students and long range planning to ensure such students, male and female, are encouraged to take advanced courses in high school as described by Casserly (1980) seem to be desirable.

If advanced mathematics is to remain optional, perhaps some courses could be designed to appeal more to those girls who have strong social and aesthetic interests. Advanced mathematics courses

are typically designed with a theoretical rather than an applied focus at the high school and college level. There is no reason why much of "good mathematics" can't be taught within the context of the uses of mathematics in the social sciences or architecture and urban planning Some efforts to rename and "humanize" mathematics courses have been made at the college level in such schools as Wellesley.

More basic changes might be made in mathematics instruction in the future if research efforts reveal any information processing differences or cognitive differences between the sexes. If many females do, indeed, have a spatial deficit that is not a function of early learning experiences (i.e., differential play with manipulative toys in pre-school years), then perhaps calculus as it is currently taught is not as appropriate for these women as some other approaches might be At present, we know too little about sex differences in the organization and operation of the brain to do more than speculate about these matters

Several research studies suggest that attitudes and behaviors of parents and teachers are important to the development of female mathematicians and girls who do elect to study advanced placement courses in calculus and the physical sciences. Therefore, the development of training and counseling programs for parents and teachers may be very critical. Indeed, if all parents, teachers, and the general public were sensitized to their sexist beliefs and changed their attitudes and behaviors, the mathematical mystique might vanish into the air without any other intervention being necessary. It may be that parent and teacher training is the key to eventual prevention of mathematics avoidance and/or feelings of low confidence and ignorance of the value of the study of mathematics.

Prevention. Although constructing an ideal world is probably impossible, we can identify home, school, and societal conditions which might give rise to an androgynous view of mathematics and related careers. Thus, we can speculate as to what life and school might be like in a world where boys and girls were similarly encouraged to develop interest and competence in mathematics and all career areas were considered equally acceptable or possible for women and men.

In an ideal home of the future (with respect to mathematics learning) parents' expectations and aspirations for their children with respect to mathematics learning and careers would not be a function of the children's sex. College and career plans would be discussed with girls as often as with boys. Boys and girls in all families would have equal access to toys that involve spatial or mechanical manipulation, such as

blocks, dump-trucks, etc., and would receive the same positive reinforcement for playing with such toys as they would for play with dolls or coloring books. In such a home, intellectual achievements would be valued equally with social and physical achievements for both sexes. Household chores would not be assigned on the basis of old sex-role stereotypes

When children left this ideal home to go to school, they would find no textbooks or tests that reflected sex-role stereotypes, mathematics required for everyone, career counseling and career education part of the basic school program, and stressed nonstereotyped views of women and men in the world of work. In such a school mathematically gifted boys and girls would receive similar good treatment and none would be viewed as "odd" or "misfits" by teachers or peers. Indeed, in such schools mathematical competence, intellectual risk-taking, curiosity, and high levels of achievement would be expected and respected equally for boys and girls.

Such nurturing conditions in the home and school would need to be reinforced in the larger society as a whole. Thus, advertising, comics, television, and so forth, would not carry sexist messages such as a stereotyped picture of a mathematically inept female model seeking help from a stereotyped logical and competent male model. If stupidity can not be erased as a source of humor, at least it would be equally probable for men and women to be equally stupid about mathematics. More important, perhaps, than the messages of the media may be the messages to women about their true place in the world of work. If hiring, promotion, and salary discrimination exist, and if society seeks to "punish" or at least burden the working mother with extra responsibilities and guilt, then we must expect the story told in school or at mother's knee of equality and of "anything you want to be" will be as harmful and cruel a myth as the other, older myth of the mathematical mystique.

In our modern technological society, an understanding and appreciation of mathematics is becoming more and more important in almost every aspect of human endeavor. If women are to participate equally with men in solving life's day-to-day problems and designing the shape of the future, they should not be encouraged or allowed to avoid the study of mathematics. It is hoped that the research and ideas discussed here will stimulate each reader to examine his or her own ideas and behaviors with respect to women and the mathematical mystique.

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